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(54) **MERCURY FREE COLD CATHODE LAMP INTERNALLY COATED WITH A LUMINESCENT DOWN SHIFTING LAYER**

(57) A mercury free cold cathode discharge lamp generally known as neon tube using mercury free gases as a source of ultraviolet rays that excites a luminescent down-shifting (LDS) layer for generating visible light. Luminescent down-shifting (LDS) material absorbs UV radiation, with higher efficiency than phosphors, and re-emits light at a longer wavelength, in the visible spectrum.

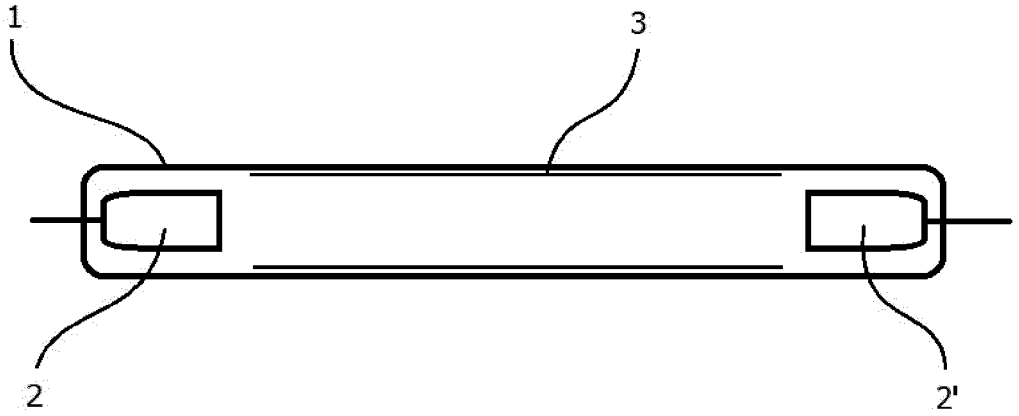

Fig. 1

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Description

Subject of Invention

[0001] The subject of the present invention is a cold cathode gas discharge lamp using mercury free noble gases as a source of ultraviolet rays that excite a luminescent down-shifting (LDS) layer for generating visible light.

Technical Problem

[0002] A technical problem solved by this invention is how to provide a cold cathode discharge gas lamp using mercury free gases as a source for generating ultraviolet rays which can substitute existing cold cathode discharge gas lamps such as mercury vapour discharge lamp, generally known as neon tubes, banned by EU Directives and Regulations.

Prior Art

[0003] In related discharge lamps, a noble gas such as Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr) or Xenon (Xe) or a mixture of the same and a certain amount of mercury (few hundreds milligrams) are sealed within a glass tube, the inner surfaces of which have been coated with fluorescent material (phosphors). The application of a high electric field (high voltage) across electrodes - provided at the two ends of the glass tube - produces a discharge in the mercury vapour and the gas mixture. The mercury that has been excited by the discharge emits ultraviolet rays upon transitioning to the normal state and the fluorescent material is excited by the emitted ultraviolet rays and gives off visible light.

[0004] The use of mercury in low-pressure discharges for advertising and lighting applications has been standard technology for several decades. Mercury as a source of UV is favoured because of its low ionisation potential (10.4 eV) and its high vapour pressure. Phosphors coating on the inside of the lamp walls convert the resonant radiation (mainly 253.4 nm) into visible radiation, which combines with the mercury visible emissions at the blue and green part of the spectrum (404.7 nm, 435.8 nm and 546.1 nm) to produce the desired white light and/or other colours.

[0005] With the adoption of the Regulation of the European Parliament 852/2017/EU on the banning of exports and the safe storage of metallic Mercury - which took effect since 31/12/2018 - Mercury cold cathode lamps became forbidden. In the same time the Minamata Convention on Mercury (a global treaty to protect human health and the environment from the adverse effects of mercury) was adopted at a Conference held in the Japanese City, with the same goals and is already in force since Jan. 1st 2021.

[0006] In the past years there have been attempts to use Xenon instead of Mercury on phosphor coated tubes as an ultraviolet source; Xenon discharge lamps did show low luminous efficacy and a proneness to discharge contraction.

[0007] Phosphors are Rare Earths based components (due to lesser concentration in the earth's crust and consequently traded at higher prices), i.e. a group of 17 elements with similar characteristics. They comprise the group of Lanthanides plus the elements Scandium and Yttrium. While the trade dispute between the US and China has reached a point where export restrictions on Rare Earths have become a possible means for sanction, cold cathode industry could be affected as well and should be prepared to mitigate supply disruptions or shortage in Rare Earths trade.

[0008] Phosphors can be replaced by Nanoparticles (NPs), tiny materials having size from 1 to 100 nm. They can be classified into different classes based on their properties, shapes or sizes. NPs possess unique physical and chemical properties due to their high surface area and nanoscale size. Their optical properties are reported to be dependent on the size, not on the material, which imparts different colours due to absorption of the exciting UV radiation.

Solution to the Technical Problem

[0009] The above described technical problem is solved by a mercury free cold cathode lamp that can achieve a lighting emission comparable with that of a prior art mercury vapour discharge lamp.

[0010] The mercury free cold cathode lamp of the present invention is a cold cathode lamp in which at least Xenon gas - preferably in a percentage not exceeding 10% - and another noble gas (i.e. Neon) or a mixture of other gases are enclosed and includes a sealed glass tube internally coated with a layer of luminescent down-shifting (LDS) material, with a thickness ranging from 10 to 50 μm approximately. The filling pressure of the gas mixture shall not exceed 6.600 Pa approximately.

[0011] NPs as a component of the luminescent down-shifting (LDS) layer can be used as alone or in addiction to standard phosphors or other chemical optically inert components; while better results can be achieved with a coating made of pure NPs layer, nowadays a good compromise in terms of light efficacy and raw material cost recommends a mixture of both components. Once the NPs will be produced in large scale a fully NPs coating will be economically affordable by cold cathode industry.

[0012] The luminescent down-shifting (LDS) layer absorbs photons, typically in the 200÷500 nm range, and re-emits them at a longer wavelength, in the visible spectrum. The energy conversion efficiency of NPs is generally higher compared with traditional Rare Earths based Phosphors, assuring a better energy efficacy than prior art mercury discharge lamps.

[0013] In the specification, explanation regarded a case in which a mixture of Xenon gas and Neon gas is used as discharge gas, but the gas that is mixed with

Xenon gas is not limited to Neon gas and a desired gas such as Helium (He), Argon (Ar), Krypton (Kr) or any mixture of the same or other gasses can also be selected. In the present example, high voltage can be applied either in high frequency (i.e. 20 kHz or above) as well as at 50/60 cycles, using standard neon power supplies.

[0014] The above and other objects, features and advantages of the present invention will become apparent from the following descriptions with reference to the accompanying drawing

FIG. 1 a schematic sectional view showing an embodiment of the cold cathode lamp

[0015] The following description concerns the details of a standard cold cathode lamp with reference to FIG. 1 where a schematic sectional view shows its typical components: a cold cathode lamp is made of a sealed glass tube 1 with two electrodes 2, 2' arranged on each tube ends.

[0016] The inner surface of the glass tube 1 is coated with a layer 3 of luminescent down-shifting (LDS) material, with a thickness ranging from 10 to 50 μm approximately. Such a luminescent down-shifting (LDS) layer 3 can be used as alone or in addiction to standard phosphors or other inert components.

[0017] The filling pressure of the gas mixture shall not exceed 6.600 Pa approximately.

[0018] Although a cold cathode lamp of the internal electrode type was described as an example of an embodiment of the present invention, the invention can also be applied to a cold cathode lamp of the external electrode type, normally known as EEFL (external electrode fluorescent lamp). Cold cathode lamps can be shaped in any form, i.e. linear, bended, circular, etc.

[0019] While a preferred embodiment of the present invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit of scope of the claims. In the same way, the filling pressure of the gas mixture will not affect the spirit of scope of the claims.

Claims

1. A mercury free cold cathode lamp in which electrodes are arranged at the two ends of a glass tube (1) in which pure Xenon or Xenon and another gas or gasses are enclosed, **characterised in that** the inner surface has been coated with a layer (3) of luminescent down-shifting (LDS) materials.

2. A mercury free cold cathode lamp in which, according to claim 1, wherein said luminescent down-shifting (LDS) materials comprise some Nanoparticles (NPs) having size ranging from 1 to 100 nm.

3. A cold cathode lamp according to claim 2, wherein said luminescent down-shifting (LDS) materials comprise a mixture of NPs and standard phosphors in any percentage.

4. A cold cathode lamp according to claim 3, wherein said luminescent down-shifting (LDS) materials include chemical additives.

5. A cold cathode lamp according to claim 4, wherein said luminescent down-shifting (LDS) materials are sealed into a glass tube (1) filled with pure Xenon or Xenon and another gas or gasses.

6. A cold cathode lamp according to claim 5, wherein said sealed glass tube (1) is provided with at least two electrodes (2, 2') at both ends.

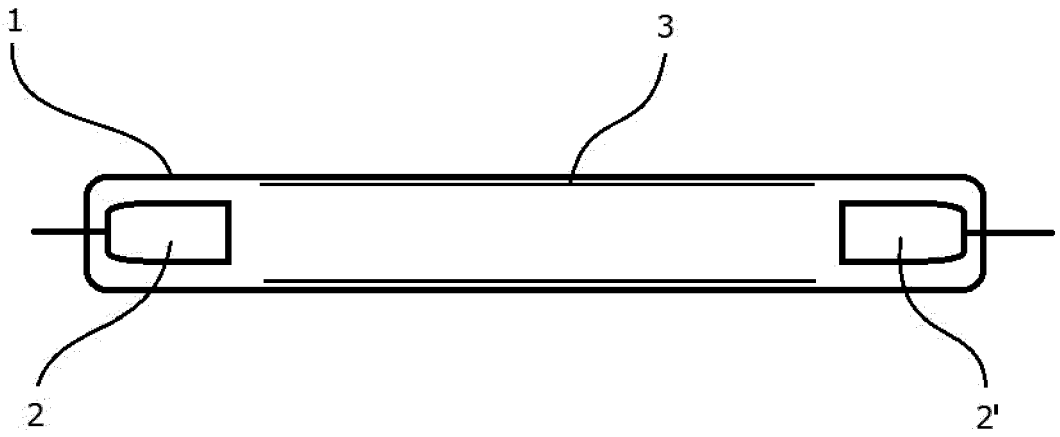

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 22 18 7122

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 December 2022	Schmidt-Kärst, S

CATEGORY OF CITED DOCUMENTS

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